

Kinematics

For constant speed: $d = Vt$ $V_{\text{total}} = \frac{d_{\text{total}}}{t_{\text{total}}}$

For acceleration: $V_f = V_i + at$ $d = \frac{(V_i + V_f)t}{2}$ $d = V_i t + \frac{1}{2}at^2$ $V_f^2 = V_i^2 + 2ad$
 $d = x - x_o$ $x = x_o + V_o t + \frac{1}{2}at^2$

Uniform Circular Motion/Rotational Kinematics

$V_t = \frac{2\pi r}{T}$ or $\frac{(\# \text{ of rpm})(2\pi r)}{60}$ $s = r\theta$ $\omega = \frac{\Delta\theta}{\Delta t} \left(\frac{2\pi}{T}\right)$ $\alpha = \frac{\Delta\omega}{\Delta t}$
 $a_c = \frac{V_t^2}{r}$ $\omega_f = \omega_i + \alpha t$ $\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$ $\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$
 $V_t = \omega r$ $a_t = \alpha r$

Vectors

$X_{\text{comp}} = R\cos\theta$ $Y_{\text{comp}} = R\sin\theta$ **Center of Mass** $C \text{ of } M = \frac{(m_1 P_1 + m_2 P_2 + m_3 P_3 + \dots + m_{ms} P_{ms})}{(m_1 + m_2 + m_3 + \dots + m_{ms})}$

$X^2 + Y^2 = R^2$ $\tan\theta = \frac{Y}{X}$ (vector direction only)

Projectile Motion

$V_x = V\cos\theta$ $V_{iy} = V\sin\theta$ $d_x = V_x t$ $t_{\text{type 1}} = \sqrt{\frac{d_y}{4.90}}$
 $d_y = V_{iy} t - 4.90t^2$ $V_{fy} = V_{iy} - 9.80t$ $d_x = \frac{V^2(\sin 2\theta)}{9.80}$ $t_{\text{type 2}} = \frac{2V_{iy}}{9.80}$

Newton's 2nd Law and Gravity

$\Sigma F = ma$ $W = mg$ $F_{sp} = -k\Delta x$ $F_c = \frac{mV_t^2}{r}$
 $F_f = \mu F_n$ $W_x = mg\sin\theta$ $W_y = mg\cos\theta$ **2-Body:** $a = \frac{\text{net force}}{\text{total system mass}}$
 $F_g = \frac{Gm_1 m_2}{r^2}$ $g = \frac{GM}{r^2}$ $V_{\text{orb}} = \sqrt{\frac{GM}{r}}$ $U_G = \frac{-Gm_1 m_2}{r}$
 $G = 6.672 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2}$

Work, Power, Energy & Efficiency

$W = F_{\parallel} d = Fd\cos\theta$ $P = \frac{W}{t}$ $P = F_{\parallel} V_{\text{avg}}$ $V_{\text{esc}} = \sqrt{\frac{2GM}{r}}$
 $U_g = mgh$ ($mg\Delta y$) $U_e = \frac{1}{2}k(\Delta x)^2$ $K = \frac{1}{2}mV^2$ $\text{Efficiency} = \left(\frac{E_{\text{out}}}{E_{\text{in}}}\right) \times 100\%$
 $W = K_f - K_i$ and $W = U_{gf} - U_{gi}$ $mgh_i + \frac{1}{2}mV_i^2 = mgh_f + \frac{1}{2}mV_f^2$ (ideal)
 $U_{ei} + K_i = U_{ef} + K_f$ (ideal)

Percent Error

$\% \text{ error} = \left(\frac{|A - O|}{A}\right) \times 100\%$

name _____

d = distance
 V = velocity or speed
 i = initial
 f = final
 t = time
 a = acceleration
 x = position
 x_o = initial position
 r = radius, distance, or position
 T = period
 s = arc length
 ω = angular velocity
 Θ = angle
 Δ = change
 α = angular acceleration
 a_c = centripetal accel.
 V_t = tangential velocity
 a_t = tangential accel.
 a_r = radial acceleration
 X_{comp} = x component
 Y_{comp} = y component
 R = resultant vector
 m = mass
 P = position
 x = x direction
 y = y direction
 g = accel. due to gravity (9.80 m/s^2)
 Σ = sum of
 F = force
 W = weight
 F_{sp} = spring force
 k = spring constant
 F_c = centripetal force
 F_f = force of friction
 μ = coefficient of friction
 F_n = force normal
 F_g = force of gravity
 V_{orb} = orbital velocity
 W = work
 P = Power
 V_{esc} = escape velocity
 U = Potential Energy
 U_e = elastic PE
 K = Kinetic Energy
 x = displacement
 E_{out} = Energy out / final
 E_{in} = Energy in / initial
 A = accepted
 O = observed

Momentum

$L = \text{angular momentum}$

$$I = Ft \text{ or } I = m\Delta V$$

$$Ft = m\Delta V$$

$$p = mV$$

$$m_1V_{1i} + m_2V_{2i} = m_1V_{1f} + m_2V_{2f}$$

$$V_{1i} + V_{1f} = V_{2i} + V_{2f}$$

$$\text{2-D inelastic: } p_R^2 = p_x^2 + p_y^2 \quad V_f = \frac{p_R}{m_1 + m_2 + \dots} \quad \tan\theta = \frac{p_y}{p_x}$$

$$L = I\omega \text{ (rmv}\sin\theta) \quad \Delta L = \tau\Delta t \quad L_{\text{orb}} = mV_{\text{orb}}r_{\text{orb}} \quad I_1\omega_1 = I_2\omega_2 \quad K_r = \frac{1}{2}I\omega^2$$

$$\tau = Fr\sin\theta \quad W = \tau\Delta\theta \quad \Sigma\tau = I\alpha \quad I_{\text{sphere}} = \frac{2}{5}mr^2 \quad I_{\text{disc}} = \frac{1}{2}mr^2$$

$$I_{\text{hoop or point mass}} = mr^2 \quad I_{\text{rod(middle)}} = \frac{1}{12}mL^2 \quad I_{\text{rod(end)}} = \frac{1}{3}mL^2 \quad L = \text{length of rod}$$

$$I' = I_{\text{cm}} + Md^2$$

Simple Harmonic Motion (Oscillations)

$L = \text{length}$

$$f = \frac{1}{T}$$

$$T_{\text{spring}} = 2\pi\sqrt{\frac{m}{k}}$$

$$T_{\text{pendulum}} = 2\pi\sqrt{\frac{L}{g}}$$

$$X = A\cos(\omega t)$$

$$V = -\omega A\sin(\omega t)$$

$$a = -\omega^2 A\cos(\omega t)$$

$$U_e = \frac{1}{2}kx^2$$

$$U_{ei} + K_i = U_{ef} + K_f \text{ (ideal or SHM)}$$

Fluids

$$\rho = m/V$$

$$P = F/A$$

$$P_2 = P_1 + \rho gh$$

$$P_{\text{abs}} = P_G + P_{\text{atm}}$$

$$\% \text{submerged} = \frac{\rho_1}{\rho_2} \times 100\%$$

- Archimedes' Principle:** $F_{\text{buoy}} = \rho Vg$ $F_{\text{apparent}} = W - F_{\text{buoy}}$ (**W = Weight**)
- Pascal's Principle:** $F_1/A_1 = F_2/A_2$
- Mass Continuity:** $\rho vA = \text{constant}$ (**v = velocity**)
(thus for constant density $v_1A_1 = v_2A_2$)
- Bernoulli's Equation:** $P + \frac{1}{2}\rho v^2 + \rho gy = \text{constant}$ (**v = velocity**)
(thus for horizontal pipe $P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$)
- Outflow pipe velocity:** $v = \sqrt{2gh}$ (**v = velocity**)
- Flow rate (Q):** $Q = VA$ (**V=velocity**)

$$1 \text{ liter} = 10^{-3} \text{ m}^3 \quad 1 \text{ m}^3 = 10^6 \text{ cm}^3 = 264.2 \text{ gal}$$

$$1 \text{ atm} = 14.696 \text{ psi} = 101300 \text{ Pa} = 29.92 \text{ in Hg} = 760 \text{ Torr}$$

Conversions

$$\text{nano-} = 10^{-9}$$

$$\mu \text{ (micro-)} = 10^{-6}$$

$$1 \text{ m} = 100 \text{ cm}$$

$$1 \text{ m} = 1000 \text{ mm}$$

$$1 \text{ km} = 1000 \text{ m}$$

$$1 \text{ m} = 3.285 \text{ ft}$$

$$1 \text{ kg} = 2.205 \text{ lb}$$

$$1 \text{ in} = 2.54 \text{ cm}$$

$$1 \text{ mile} = 1609 \text{ m}$$

$$(\text{mph}) \times \left(\frac{1609}{3600}\right) = \frac{\text{m}}{\text{s}}$$

$$\left(\frac{\text{m}}{\text{s}}\right) \times \left(\frac{3600}{1609}\right) = \text{mph}$$

$$2\pi \text{ radians} = 360^\circ$$

I = impulse

F = force

t = time

m = mass

M = mass

d = distance

V = velocity

Δ = change

p = momentum

i = initial

f = final

R = resultant

Θ = angle

I = moment of inertia or rotational inertia

ω = angular velocity

L_{orb} = orbital ang. mom.

V_{orb} = orbital velocity

r_{orb} = orbital radius

K = kinetic energy

τ = torque

Σ = sum of

α = angular acceleration

r = radius

f = frequency

d = distance

T = period

k = spring constant

g = accel. due to gravity

A = amplitude (SHM)

U_e = Elastic potential energy

k = spring constant

x = displacement

ρ = density

m = mass

V = volume

P = pressure

P_{abs} = absolute pres.

P_{atm} = atmospheric pr.

P_G = gauge pres.

F = force

A = area (Fluids)

h = height

F_{buoy} = buoyant force